

is no longer associated with an increased prevalence of lateral OA. In contrast, there is an increased association between FMA and prevalence of lateral OA when FSTS is controlled for.

Conclusion: Our study shows that anatomical variations at the hip alter the mechanical but not anatomical axis of the knee, and correlate strongly with the magnitude of difference between these axes (Fig 1b). Because FSTS did not correlate with hip anatomy or FMA, the decrease in FMA is likely the result of shifting the mechanical axis in a more valgus orientation relative to the anatomical axis, rather than vice versa. Such results suggest HKA is the more robust measure with respect to association with lateral OA and the results from our regression analyses further support this claim.

129

A BIOMECHANICAL THERAPY PROGRAM FOR PATIENTS AFTER TOTAL KNEE ARTHROPLASTY – A RANDOMIZED CONTROLLED TRIAL (PRELIMINARY RESULTS)

E.M. Debbi[†], B. Bernfeld[‡], M. Soudry[§], M. Salai^{||}, Y. Laufer[¶], A. Herman[#], A. Haim[†], A. Wolf[†]. [†]Biorobotics and Biomechanics Lab, Faculty of Mechanical Engineering, Technion Israel Inst. of Technology, Haifa, Israel; [‡]Dept. of Orthopedic Surgery, Carmel Med. Ctr., Haifa, Israel; [§]Dept. of Orthopedics, Rambam Med. Ctr., Haifa, Israel; ^{||}Div. of Orthopedics, Sourasky Med. Ctr., Tel Aviv, Israel; [¶]Dept. of Physical Therapy, Faculty of Social Welfare and Hlth.Studies, Univ. of Haifa, Haifa, Israel; [#]Dept. of Orthopedics, Sheba Med. Ctr., Tel Aviv, Israel

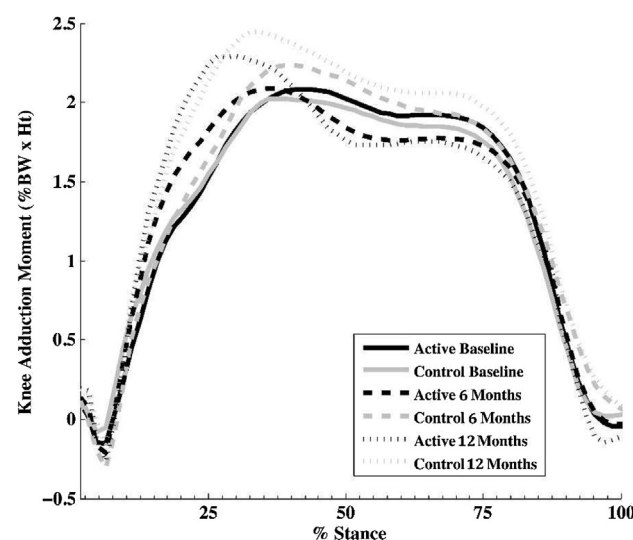
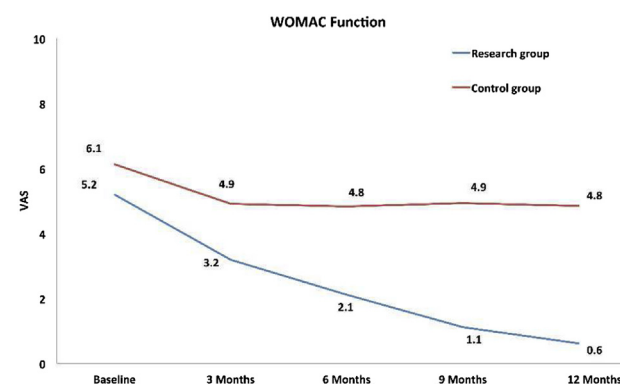
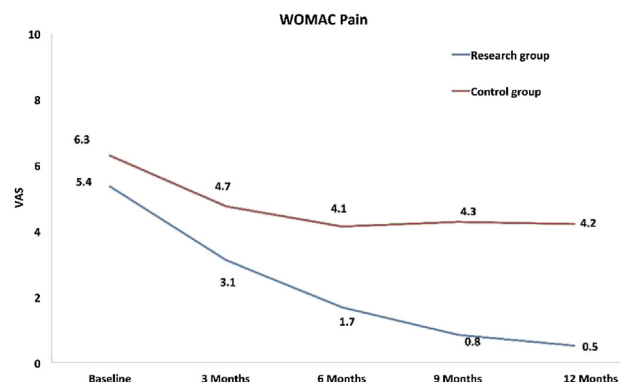
Purpose: The predicted increase in primary and revision total knee arthroplasty (TKA) for knee osteoarthritis is a major concern. The demand for primary TKA in the United States alone is expected to grow by 673% (3.48 million annual procedures) by 2030 and the demand for TKA revisions is expected to grow by 601%. Yet, up to 50% of patients continue to suffer from pain and disability following the surgery. In most of the cases those finding cannot be explained by implant factors or surgical technique. Additionally, physiotherapy functional exercises after discharge result in small to moderate effect sizes with no long-term benefits. Evidence shows that gait patterns after TKA do not return to healthy ranges. These pathological gait patterns may partially explain the difficulty in postoperative recovery in pain and function, as well the wear and tear of the TKA implant in the long-term. In this study we applied a biomechanical therapy program after surgery aimed at reducing pain, improving function and correcting gait patterns.

Methods: We conducted a randomized, controlled, double-blind trial involving fifty patients after unilateral TKA for end-stage knee OA. The active group underwent a therapy program using a biomechanical foot-worn device, while the control group received a similar training program with a sham walking shoe. Treatment was initiated 6 weeks postoperatively. Patients were examined at baseline, 3 months, 6 months, 9 months and 12 months postoperatively. Outcomes were the Western Ontario and McMaster Osteoarthritis Index (WOMAC), the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) and three-dimensional gait analysis measurements in the frontal and sagittal planes. Comparisons of categorical variables between the intervention groups (active vs. control) were carried out with the chi-square tests. Comparisons of continuous variables such as demographic data and baseline gait data between the groups were done by the Wilcoxon-Mann-Whitney rank-sum test. A linear mixed effect model was used to determine the effect of the treatment over time in each parameter.

Results: There were no differences between groups at baseline. Both groups improved with time after surgery, but the active group consistently showed significantly better outcomes in WOMAC pain (Figure 1; 91% reduction compared to 33%), function (Figure 2; 93% reduction compared to 21%) and stiffness (85% reduction compared to 32%) sub-scales (all $p = 0.001$), in SF-36 physical score (107.3% increase compared to 59%) and mental scores (51% increase compared to 45%) (all $p < 0.001$). Patients from the active group also showed lower second peak knee adduction moment (Figure 3; $p = 0.007$) and greater peak knee extension moment ($p = 0.009$). Linear mixed effect models over time showed faster improvements in the active group in all clinical parameters, stride, cadence, double-limb-support, step-length, knee range of motion and impulses of the knee flexion and extension moments, as well as slower regression of the knee adduction impulse (all $p < 0.01$). The knee varus angle did not differ between groups over time.

Conclusions: A patient-specific biomechanical therapy program applied to patients after unilateral TKA may lead to a greater improvement and more rapid recovery time in pain and function, as

compared to regular rehabilitation protocols after TKA. Furthermore, this biomechanical training program may lead to healthier loading patterns on the knee joint.



130

NEUROMUSCULAR STRATEGIES DURING GAIT IN WOMEN WITH EARLY AND ESTABLISHED KNEE OSTEOARTHRITIS

A. Mahmoudian[†], I.A. Baert[‡], I. Jonkers[†], J.H. van Dieen[§], F.P. Luyten[†], S.M. Verschueren[†]. [†]KU Leuven, Leuven, Belgium; [‡]Univ. of Antwerp, Antwerp, Belgium; [§]VU Univ., Amsterdam, Netherlands

Purpose: Osteoarthritis (OA) has become one of the leading causes of pain and disability in the elderly worldwide. Medial compartment knee

joint loading during gait, measured indirectly by calculating the external knee adduction moment (KAM), has received the most attention due to its crucial role in knee OA pathogenesis. In a recent study of our group, we showed in this respect that women with "early" knee OA as defined by Luyten et al., did not demonstrate an altered loading pattern yet, whereas women with established OA did show an increased KAM during gait. The neuromuscular adaptations during gait in patients with knee OA have received less attention especially in patients with early OA. The aim of the present study is to assess the differences in gait related neuromuscular activity in subjects with early OA compared to healthy controls and established OA patients.

Methods: Eighty-five women enrolled in the present study. Knee OA patients were sub-classified into early ($n = 27$) and established ($n = 29$) medial knee OA groups based on the recent classification system for early OA, which combines magnetic resonance imaging with radiographic and clinical findings. Twenty-nine age-matched asymptomatic subjects formed the control group. Knee symptoms and function were evaluated using the Knee Injury and Osteoarthritis Outcome Score (KOOS) (Dutch version). 3Dgait analysis was performed whereby bilateral muscle activity of rectus femoris (RF), Medial Hamstrings (MH), vastus lateralis (VL), vastus medialis (VM), gluteus medius (GM), and gastrocnemius (GC) was recorded with surface electromyography (EMG). The EMG was normalized to the peak muscle activity of each muscle found within each walking trial. Afterwards the mean and maximum EMG activities were calculated. Co-contraction indices (CCI) were calculated for 3 pairs of muscles (VM-MH, VM-MGC, and VL-MH) using the method of Rudolph et al. (2000).

Results: Subjects with established OA had significantly lower knee symptoms and function scores on KOOS compared to healthy controls or patients with early OA. There were no significant differences between the three groups in the mean normalized muscle activity during the stance phase of gait. Comparing mean activity of the two vasti muscles during the stance phase of gait within each group, however, revealed that the patients with established OA had a significantly higher activity of vastus lateralis compared to vastus medialis ($p = 0.05$) in the involved leg but not in the contralateral leg. There was no difference between the 3 groups in duration of muscle activation as percentage of the stance phase of the gait cycle. The CCI for the Medial Gastrocnemius-Vastus Medialis was decreased in the early OA group compared to the healthy controls and the established OA group, although this difference did not reach significance ($p = 0.09$).

Conclusions: Patients with early OA did not show similar alterations in neuromuscular control compared to the established OA patients. The tendency of patients with early OA to decrease medial co-contraction might be a strategy to reduce medial compartment knee joint loading. Comparable to previous studies, patients with established OA showed some neuromuscular adaptations, such as an increased activation of vastus lateralis compared to vastus medialis. Other previously reported findings, like an increased duration of muscle activation, were not replicated in this study. Neuromuscular adaptations during gait appear to occur later in the disease process, thus they probably aren't risk factor in knee OA pathogenesis.

131

BASELINE THREE-DIMENSIONAL KNEE JOINT BIOMECHANICS AND MUSCLE ACTIVATION PATTERNS DIFFER BETWEEN THOSE WITH MODERATE OA WHO HAVE RADIOGRAPHIC PROGRESSION VERSUS THOSE WHO DO NOT

C.L. Hubley-Kozey, K.E. Costello, G.L. Hatfield, J. Astephen-Wilson, W.D. Stanish. *Dalhousie Univ., Halifax, NS, Canada*

Purpose: Recent management strategies for knee osteoarthritis (OA) include biomechanical interventions, but few longitudinal studies have linked biomechanics to progression. For structural progression the focus has been on knee adduction moment features (first peak and impulse), whereas both frontal and sagittal plane moments have been linked with progression to total knee arthroplasty (TKA). As both 3D moments and muscle forces contribute to overall joint loading, this preliminary study sought to determine differences in knee joint muscle activation patterns and 3D biomechanics during gait in individuals with medial compartment knee OA who progressed structurally after long-term follow-up versus those who did not.

Methods: 56 individuals with moderate medial compartment knee OA (i.e. high function/not TKA candidates) completed baseline isometric strength assessment of plantar flexors, knee extensors and flexors using

a Cybex isokinetic dynamometer. 3D lower limb motion and ground reaction forces were recorded during walking at a self-selected speed along with surface electromyograms (EMG) from 7 muscle sites (medial/lateral gastrocnemius and hamstrings, vastus lateralis/medialis, and rectus femoris). Standard anterior posterior X-rays were taken at baseline and 8.1 ± 1.5 years later with medial tibio-femoral joint space narrowing (JSN) scored at each time point by a high volume orthopaedic surgeon (WDS). 3D angles were expressed in the joint coordinate system and external moments were calculated using inverse dynamics and normalized to body mass (Nm/kg). Peak knee adduction moment was calculated. Shape and magnitude features for biomechanics and EMG waveforms were extracted using Principal Component Analysis, and each participants' waveforms were scored based on how closely they matched extracted patterns. Progression was defined as increased JSN score at follow-up. Between-group differences were identified with t-tests ($\alpha = 0.05$).

Results: Nineteen participants with maximal baseline JSN scores (JSN = 3) were excluded. Of the 37 remaining, 21 progressed based on JSN scores. There were no baseline differences in demographics (age = 57 years, body mass index = 31 kg/m^2), isometric strength, walking velocity (1.2 m/s), or WOMAC scores (33) between the groups ($p > 0.05$). Those that progressed were slightly higher functioning (SF36: 74.7 vs. 63.5, $p < 0.05$), had lower overall knee flexion moment magnitude ($p < 0.05$) and had a phase shift in peak internal rotation moment to earlier in stance ($p < 0.01$). Peak knee adduction moment was 19% higher in the progression group, but was not statistically significant. For the EMG characteristics, those that progressed had a shift in lateral gastrocnemius activity to earlier in the stance phase ($p = 0.05$). The no progression group appeared to have prolonged medial hamstring activity during stance but this difference was not significant ($p = 0.06$).

Conclusion: While previous studies have linked knee adduction moment features with structural OA progression, the present study found a relationship between progression and both sagittal and transverse plane features; the former related to a sustained flexion moment and the latter related to joint shear due to rotation moments. The phase shift in lateral gastrocnemius activity is consistent with the altered rotation feature and a more atypical rotational pattern. Altered sagittal and frontal plane loading has also been linked to TKA progression, although the sustained loading characteristics associated with TKA progression were not present here. This is the first study to provide preliminary evidence linking both sagittal and rotational gait mechanics to OA progression in human studies supporting the inclusion of additional biomechanical targets in management strategies to slow structural disease progression.

Funding from Canadian Institutes for Health Research (CHK) and Trainee support from Nova Scotia Health Research Foundation (KEC).

132

CHANGES IN JOINT LOADS, LEPTIN, AND MMP-3 SUBSEQUENT TO LONG-TERM INTENSIVE WEIGHT LOSS AND EXERCISE: SECONDARY OUTCOMES FROM THE INTENSIVE DIET AND EXERCISE FOR ARTHRITIS RANDOMIZED CLINICAL TRIAL

S.P. Messier[†], P. DeVita[‡], B.J. Nicklas[§], D. Beavers[§], G.D. Miller[†], D.J. Hunter^{||}, F. Eckstein[¶], A. Guermazi[#], R.F. Loeser^{††}. [†]Wake Forest Univ., Winston-Salem, NC, USA; [‡]East Carolina Univ., Greenville, NC, USA; [§]Wake Forest Sch. of Med., Winston-Salem, NC, USA; ^{||}Univ. of Sydney, Sydney, Australia; [¶]Paracelsus Med. Univ., Salzburg, Austria; [#]Boston Univ., Boston, MA, USA; ^{††}Wake Forest Univ. Sch. of Med., Winston-Salem, NC, USA

Purpose: Obesity is one of the most modifiable risk factors for symptomatic knee osteoarthritis (OA), and dietary induced weight loss combined with exercise is potentially the best non-pharmacologic treatment. We report secondary outcomes of a randomized clinical trial designed to test the hypothesis that intensive weight loss, either with or without exercise, will reduce knee joint loads, and serum Leptin and MMP-3 levels.

Methods: The Intensive Diet and Exercise for Arthritis (IDEA) trial was an 18-month prospective, single-blind, randomized controlled trial that enrolled 454 overweight and obese (BMI = $27\text{--}41 \text{ kg/m}^2$) older (age ≥ 55 yrs) adults with pain and radiographic evidence of tibiofemoral OA. Participants were randomized to one of three 18-month interventions: intensive dietary- induced weight loss-plus-exercise (D+E); intensive dietary-induced weight loss-only (D); or exercise-only (E). The weight loss goal for the two diet groups was $\geq 10\%$ of baseline body weight. Exercise included low-to-moderate intensity walking and resistance